Cover-Biomass Relationships in Woody Plants: Effects of Fire and Implications for Remote Sensing

Cho-ying Huang[a,b], Stuart Marsh[b], Mitchel McClaran[a], and Steven Archer[a]

Introduction and Problem Statement

- Woody cover is known to be highly correlated with woody plant aboveground live biomass (ALB);

- Woody plant structure (e.g. canopy area, height, basal area, etc.) is influenced by land use history and disturbance;

- The recovery of woody plants from disturbances such as wild fire may be via a combination of seedling establishment and vegetative regeneration;

- *Therefore, do woody plant canopy area-ALB relationships differ on landscapes with contrasting fire histories? How rapidly does woody plant cover and biomass recover following wildfire in a semi-desert grassland?*

Objectives

- Quantify relationship(s) between woody cover and ALB in burned and unburned areas at a plot scale (40 × 20 m);

- Determine if a knowledge of fire history influences the ability of remotely sensed data to estimate woody ALB.

Methods

1. Study site: The Santa Rita Experimental Range

- A 200 km² area approximately 35 km south of Tucson; established in 1903.

- Elevation: 884 to 1585 m. Annual precipitation bi-modally distributed; increases gradually along the elevation gradient: 250 mm in dry years and 500 mm in wet years at 1200 m.

- Mean annual temperature: 18° C at the elevation of 1310 m (Std Dev = 6.5° C).

2. Derive fire intensity using Landsat TM

- Our study focused on the *Prosopis velutina* - desert grassland elevation zone in an area subject to wildfires in 1989 and 1994. Spatial variation in fire intensity within this area was derived from Landsat TM images right before and after fire.

dNBR
100 - 150
150 - 200
200 - 250
250 - 300
300 - 350
> 350
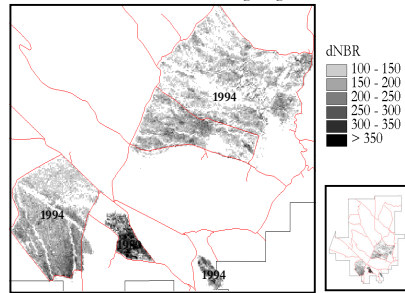
$NBR = 1000[(\rho_{NIR} - \rho_{SWIR})/(\rho_{NIR} + \rho_{SWIR})]; dNBR = NBR_{pre} - NBR_{post}$

Note that higher dNBR values indicate more biomass lost during fire.

3. Sampling

- Sampled twenty 40 × 20 m plots. Control plots (n=8) were randomly selected within areas which have not burned for at least the past 21 years; burned plots (n = 12) represent a range of severity index values;

- Computed canopy area for each individual shrub and cactus patch in plots as a circle or an ellipse; estimated ALB using previously established allometric equations.
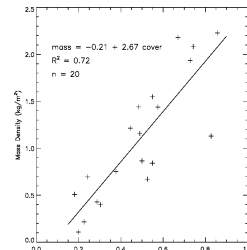
Results

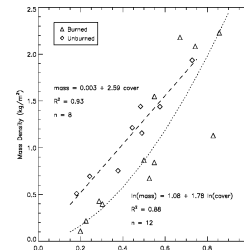Figure 1: Woody ALB vs. cover.

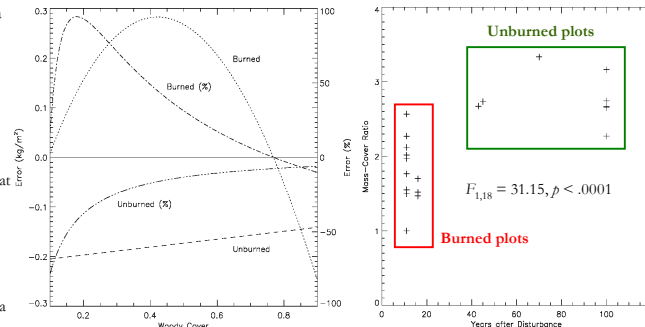Figure 2: Woody ALB vs. cover (burned vs. unburned)

Figure 4: Potential error estimating ALB without taking into account fire history.

Figure 5: Recovery of *Prosopis velutina* mass-to-cover ratio following fire in 1989 and 1994. Plants with canopy area > 26.42 m² were presumed to have escaped fire so were not included in the analysis.

$F_{1,18} = 31.15, p < .0001$
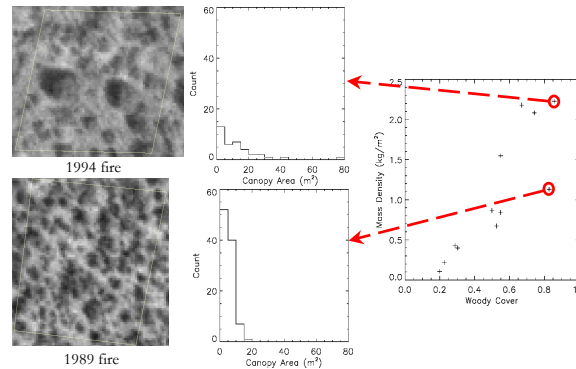

1994 fire

1989 fire

Figure 3: Woody plant community structure in semiarid savannas after fire vary based upon fire intensity. The highly intense 1989 fire burned away most cover and the current condition reflects gradual re-growth of youth woody plants. The lower intensity 1994 fire left existing trees intact so that now there is more diversity in ALB.
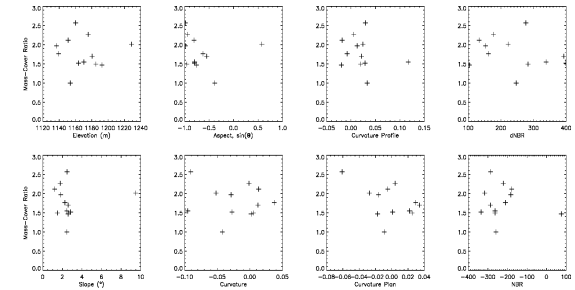

Figure 6: The relationships between physical environment/fire intensity, and mass-cover ratio of woody plant after fire.
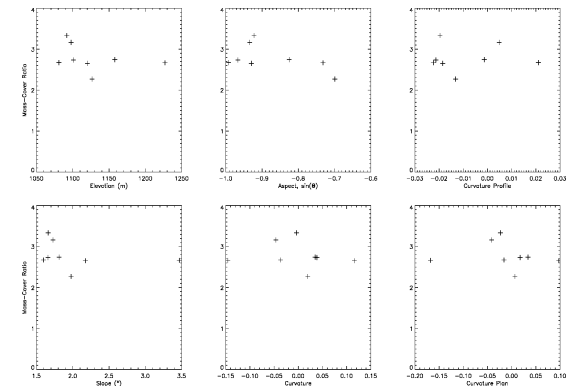

Figure 7: The relationships between physical environment and mass-cover ratio of woody plant in unburned settings.

Conclusions

- Cover is a strong predictor of ALB at the plot scale and fire history can significantly affect the nature of ALB-cover relationship;

- Simple predictions of ALB from cover will underestimate ALB in unburned plots, and overestimate ALB in recently burned locations;

- Canopy cover of disturbed *Prosopis velutina* recovers faster than ALB;

- Fire intensity does not differentiate the recovery of woody plants;

- The influences of physical environment (elevation, slope, aspect, and curvature) on woody plants mass-cover ratio are not pronounced regardless of the burn and unburn treatment.

[a] School of Natural Resources, University of Arizona; [b] Arizona Remote Sensing Center, Office of Arid Lands Studies, University of Arizona